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A CONTRIBUTION TO THE STUDY OF PYOCYANEUS INFECTIONS WITH A REPORT OF TWO RARE CASES.*

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IN reviewing the literature of pyocyaneus infections, one is at once struck with the increased frequency with which the germ is encountered, either alone or in association with other organisms, since the introduction of improved methods in the bacteriological examination of material from pathological lesions, has been more widely adopted. The pyocyaneus bacillus has been found in pure culture in all parts of the body, in localized lesions and in general systemic infections. In not a few instances it has been isolated in pure culture from the blood during life. By some it is believed that when this germ is found it is not the cause of the original lesion but that it makes its appearance only after some other organism, having brought about a lowered tissue resistance, has prepared the soil for it and has then disappeared. This explanation may be tenable in many instances but there are others where there can be very little doubt that *B. pyocyaneus* is the primary and sole cause of the lesion.

INFECTIONS OF THE EAR.

Certain parts of the body seem to be attacked with greater frequency than others, the middle ear appearing to be especially prone to such infections. Sometimes from this focus, which is localized in the beginning, there is an extension to the meninges or a general invasion of the body may take place.

In acute otitis media I have collected from the literature 21 instances of pure infection and 15 of mixed. A few more have been recorded, but I was unable to verify the reports from the original sources.

Among the earlier investigators who have reported the presence of the *B. pyocyaneus*, either in pure culture or in association with other organisms in otitis media, mention should be made of Babes.[1]

* Received for publication July 20, 1908.

Bloxall[2] reports one case of acute otitis media following scarlet fever which was due to this germ. Chambers,[3] in the examination of the pus from 58 cases of otitis media purulenta, found it present in pure culture six times, twice associated with *Strept. pyogenes,* and twice with *Strept. pyogenes* and *Staph. aureus.* The discharges were profuse and fetid and if imprisoned had a green color. Danilovič[4] and Finkelstein[5] have isolated it and Funke[6] obtained it twice in pure culture and eight times in association with other bacteria in the examination of the discharges from 76 cases of otitis media. Green[7] in the examination of 73 cases of pure infection in acute suppuration of the tympanum met with it three times; in 28 cases of mixed infection it was present once in association with *Staph. aureus.* In 112 cases of mastoiditis in which a pure culture was present it was found eight times. Gruber[8] and Harbitz[9] have reported its presence, and Hasslauer[10] records 17 cases of primary middle ear disease with spontaneous perforation in which it was the specific cause twice. Helmann[11] found it in pure culture in three cases of otitis externa crouposa. In Horder's[12] case of chronic bilateral otitis media with perforated tympanum, which had existed for several years, there was an acute exacerbation which lasted for five weeks, terminating in paraplegia and death. From the pus in both middle ears, small abscesses in the lungs, and from the pus in the meninges extending from the mid-dorsal region to the cauda equina it was obtained in pure culture, but not from the spleen or blood. No other organism was present in any material examined. Kanthack[13] reports nine cases of chronic otitis in which it was usually encountered with other bacteria. Of the bacilli present only *B. pyocyaneus* was pathogenic. Kossel[14] investigated bacteriologically 38 cases of inflammation of the middle ear post mortem. Three times *B. pyocyaneus* was present in pure culture, once in association with a pseudo-influenza bacillus. In one of these cases there was a severe gastritis, the stomach contents showing this germ in large numbers. The feces were stained a characteristic green. Lermoyez[15] isolated *B. pyocyaneus* in pure culture from a case of perichondritis of the ear muscle. This bacillus proved to be pathogenic to rabbits. Leutert[16] in all his cases of perichondritis of the ear, four in number, found this organism present in pure culture. Maggiora and Gradenigo[17] found it associated with *Staph. albus* in small numbers in a furuncle of the external auditory canal. They believed that *B. pyocyaneus* was the cause of the trouble. Martha[18] encountered it twice in pure culture in the examination of 53 cases of purulent otitis media. Pes and Gradenigo[19] isolated it twice in pure culture from 15 cases of acute purulent otitis media. Rohrer[20] also records its presence in the discharge from an acute purulent otitis media which had ruptured spontaneously. Ruprecht[21] describes a case of otitis externa crouposa from which on the fifth day of the membrane formation a pure culture of pyocyaneus was obtained. Tatsusaburo[22] adds another to the list of cases of perichondritis of the external ear in which this organism was present in pure culture. Voss[23] has contributed to the literature of pyocyaneus infections of the ear.

INFECTIONS OF THE EYE.

Among those who have isolated this organism in infections of the eye are de Berardinis[24] and Derby.[25] Hanke[26] has reported a case of ring abscess of the cornea from which he isolated an organism belonging in all probability to the pyocyaneus group. It was pathogenic for mice and infection of the anterior chamber of the eye of a rabbit produced a typical ring abscess. Happe[27] obtained it in pure culture from a corneal ulcer and injected it into the center of the cornea of a guinea-pig. An ulcus serpens developed with an accompanying ring abscess. MacNab[28] reports one case with pure infection in a woman 40 years old. *B. pyocyaneus* was isolated from a round ulcer of the left eye and from the pus in the anterior chamber. Injections of cultures of this organism into a guinea-pig and two rabbits showed that it was highly virulent. It was also obtained from the cornea in an experimental infection which presented the clinical picture of an ulcus serpens. Sattler's[29] two cases of panophthalmitis resulted from an injury to the eye in each instance. The first occurred in a stone-cutter 40 years of age and the second in a woman who injured the cornea while splitting wood. Schmidt,[30] in a bacteriological investigation of 30 cases of circumscribed corneal ulcer, encountered it only once in pure culture In Szczybalski's[31] case nearly all the corneal surface was involved. Iritis and hypopyon were complications. The infection followed an injury from straw dust. The only organism found was *B. pyocyaneus.*

INFECTIONS OF THE RESPIRATORY TRACT.

Barker[32] has reported the presence of *B. pyocyaneus* mixed with other organisms in bronchiectasis. In a case of broncho-pneumonia he encountered it in the pneumonic exudate in pure culture. This infection had developed in a man who died from carcinoma, the primary focus being in the lip with extension to the mouth, pharynx, lung, and bone, and with metastases in the cervical and axillary lymph glands. Blumer[33] isolated it in almost pure culture from an acute angina which clinically resembled diphtheria. Hirschler and Terray[34] found it associated with cocci in a case of gangrene of the lung. Monnier[35] cultivated it from foci of broncho-pneumonia, and from heart blood and pleural exudate. Nabarro[36] describes a case of gangrene of the nose in which it was present. Soltmann's[37] case is particularly interesting since it occurred in a child 13 years old who had been well previous to this infection. Death occurred on the eighth day. From the hepatized areas of the lung, cultures were made which revealed only *B. pyocyaneus.* It was also found in the stomach and intestines. Its presence, in association with other bacteria in the respiratory tract, has been recorded by Stein.[38]

INFECTIONS OF THE DIGESTIVE TRACT.

In lesions of the digestive tract it has been found in carious teeth by Arkövy;[39] in lesions of the esophagus, in association with other organisms, by Barker.[40] Booker,[41] in only a few instances, found it in the examination of the intestinal contents of infants suffering from summer diarrheas. Calmette[42] has recorded an interesting investigation carried out in Cochin China to determine the cause of dysentery existing there. In 15 of 16 cases where cultures were made *B. pyocyaneus* was present in the intestinal contents and ulcers in enormous numbers. Practically no other organism grew on the plates. In some instances pure cultures were isolated from the blood. Since Calmette frequently found streptococci associated with the *B. pyocyaneus*, he is inclined to believe that it was their presence in the intestinal contents which predisposed to the pyocyaneus infection. In the light of more recent reports it seems very probable that, in some instances at least, *B. pyocyaneus* may give rise to severe intestinal lesions without the aid of any other organisms. Cook[43] has found that this germ is sometimes the cause of pulp gangrene. Cooley[44] has recently made an interesting contribution to the literature of epidemics caused by *B. pyocyaneus.* He records 28 cases of infantile diarrhea occurring in a hospital, in children ranging in age from a few weeks to 2½ years. The epidemic occurred only in bottle-fed children. The infection was probably transmitted through the milk, which was apparently contaminated from the carelessness of those who attended the babies. Cultures were made from the stools of nine typical cases. In six of these the pyocyaneus bacillus was the predominating organism. In the other three an organism similar in all other respects to that encountered in the first six, except that no pigment formation took place, was isolated. Nine deaths occurred, six of them in infirmary babies. Of the remaining three one died in convulsions attendant on an acute otitis media, another was only four weeks old, and the third had a prolonged attack with several relapses. Coyne and Hobbs[45] isolated from the contents of the appendix and periappendicular pus in a case of appendicitis *B. pyocyaneus* and *B. coli.* Cultures of the former killed rabbits in 26 hours. The colon germ was not pathogenic for this animal. Czerny and Moser,[46] and Escherich[47] contribute to pyocyaneus infections in nursing infants. Escherich observed in the children's clinic at Graz, immediately following a case of endocarditis and septicemia caused by this organism, two cases of diarrhea in children. In both cases this germ was isolated from the stools. In one case it was found in an abscess of the thigh. Death occurred and in the foci of bronchopneumonia which were present the germ was again encountered. Jakowski[48] isolated it once from a fistula of the small intestine in pure culture and once in large numbers from a fistula of the colon. Kelly[49] in the post-mortem examination of 94 cases of acute appendicitis found the pyocyaneus bacillus present in pure culture six times. In 107 chronic cases it was found only once in pure culture. Lartigau[50] reported an interesting epidemic of dysentery which occurred in 1897. Fifteen persons in all were affected. *B. pyocyaneus* was isolated from the wells from which they obtained their domestic water supply and from the dejecta of the patients. Of the 15 persons affected four died, one being an adult of 35 years, the remaining three children ranging in age from 19 months to five years. Three of these deaths occurred in one family, seven in all being infected. The one death occurring in the remaining eight cases was in a child three years old. Maggiora[51] examined the stools of 11 persons suffering from a severe epidemic of dysentery. The pyocyaneus bacillus was found five times. Monnier[52] has isolated it in a case of noma. Pottien's[53] three cases of cholera nostras are probably instances of pyocyaneus infection. However, *B. coli* was also present. They were all rapidly fatal. Salus[54] obtained this germ in pure culture, in a woman 26 years old, from a fecal fistula which had resulted from the breaking of adhesions of the intestine to an abdominal tumor of the ovary, which was removed. Thiercelin and Lesage[55] have found it in the intestinal canal in nursing infants with fever. Wollstein[56] has found it in the stomach in ulcerative gastritis.

The epidemics of dysentery described by Calmette, Cooley, and Lartigau offer some strongly convincing evidence that dysentery may be due to the pyocyaneus bacillus without the aid of other organisms as predisposing factors. In addition it is shown that these infections are not confined to young children, though of more frequent occurrence in them than in the adult.

INFECTIONS OF SEROUS MEMBRANES.

Barker[57] found, in the systematic bacteriological examination of 800 autopsies at Johns Hopkins Hospital, that the pyocyaneus bacillus was the cause of the infection in only 11 instances. Since it has been so infrequently found when systematic bacteriological examinations of intestinal contents are made, and as it is rarely present post mortem, its presence in lesions, though it be isolated post mortem, cannot be satisfactorily explained by attributing its presence to invasion after death. Of the 11 instances recorded above it was present once in a general peritonitis in a male aged 20. Death followed an operation, the pyocyaneus bacillus and the colon bacillus being present in the peritoneal exudate and on the intestines. From a mesenteric lymph gland *B. pyocyaneus* was obtained in pure culture. It was isolated once in this series from the pericardium and once in an acute endocarditis complicated with general systemic invasion. Blum's[58] case was that of a child 2½ years old. During life the bacillus was obtained in pure culture from the blood and post mortem from the heart blood and from the valves, which presented the lesions of verrucous endocarditis. Ernst[59] describes a bacillus which is probably only a variety of *B. pyocyaneus.* This organism was isolated in pure culture from the fluid removed at two different tappings in a case of tuberculous pericarditis. In the examination post mortem of 12 cases of peritonitis Flexner[60] found 10 in which there was infection. Two were found to be sterile. Of the 10 from which cultures were obtained nine were pure, one mixed. In one case the pyocyaneus bacillus was present in pure culture. In 34 cases of exogenous peritonitis it was found twice. In 60 cases of endogenous peritonitis two were sterile. Of the other 58, 37 were mixed, 21 pure. In this class the *B. pyocyaneus* was encountered three times. Kraft[61] investigated eight cases of acute general peritonitis. In one of these he obtained the *B. pyocyaneus.* Lartigau[62] isolated it in pure culture from the laparotomy wound of an acute peritonitis, and from the blood. He also obtained it from the purulent peritoneal contents in association with a few colon bacilli. In a case of acute pleuritis it was isolated in pure culture. Pakes[63] found pyocyaneus bacillus only once in the examination of 21 cases of ulcerative endocarditis. Perkins[64] grew it in pure culture from the peritoneal exudate in a fibrino-purulent peritonitis which developed after a gastro-enterostomy following the removal of a scirrhous carcinoma of the pylorus. Pevzner[65] in the examination of 18 cases of acute endocarditis encountered it once associated with Fraenkel's diplococcus.

INFECTIONS OF THE MENINGES.

B rka[66] obtained post mortem a virulent culture of the pyocyaneus bacillus from the yellow purulent deposit in the meninges of an adult. The point of entrance could not be determined, both middle ears being sound. Councilman[67] encountered it in association with the *Staph. aureus.* Kossel[68] cultivated it from the pus of the meninges of a child six weeks old. It was obtained in pure culture from the pia and from the blood in the heart. Since it was found in the pus from the middle ear it is quite probable that this was the primary focus of infection. Pĕsina and Honl[69] obtained it in association with Friedländer's bacillus in a case of purulent meningitis in an adult. Since the disease process developed with enormous rapidity they believe that it was due to the combined action of the two organisms.

INFECTIONS OF THE GENITO-URINARY TRACT.

Barker[70] has found this germ associated with other organisms in both acute and chronic cystitis. Bernhardt[71] reports a case of pyelo-nephritis with infection of the epididymis and prostate in a man 53 years old. Blumer and Lartigau[72] found it with *B. proteus vulgaris* in three cases of ascending urinary infection. In 26 cases of acute cystitis examined by Brown[73] *B. pyocyaneus* was present once in pure culture. Charrin[74] found it associated with a few streptococci in a case of puerperal fever. Hirschberg[75] grew in pure culture from the foul-smelling pus in a case of orchitis and periorchitis *B. pyocyaneus* (*a*). Jadkewitsch[76] cultivated it from the urine of a man afflicted with ulcers which also were probably due to this germ, though no cultures were made from the green pus from the ulcers. Laplace[77] encountered it in six cases of endocervicitis in association with cocci. Le Noir[78] has met with it in urinary infections. McWeeney[79] grew it from purulent urine and Motz[80] records its presence in pathological urine. Oettinger[81] found it in the urine in a case in which it was secured from the hemorrhagic vesicles on the thigh and surrounding parts in pure culture. Perkins[82] records three interesting cases of infection of the genital tract. One of these was a case of puerperal septicemia in which *B. pyocyaneus* was found in pure culture in the cerebro-spinal exudate and in the liver. In the uterus staphylococci were also present. In a second case with a complicating bronchopneumonia it was found in pure culture in the uterus, and in association with a few large unidentified bacilli in the lungs. He also isolated it from the testicle in pure culture in a case of acute orchitis.

INFECTIONS OF THE SKIN.

Adamson[83] has reported the presence of *B. pyocyaneus* in association with streptococci and staphylococci not only in the lesions but also in the heart blood and in sections of the involved tissue. Burot[84] found it in an infection of the skin with widespread ulceration which developed in the course of a severe disease. Muscular atrophy, paralysis, and contractures developed during the course of the disease. The bacillus was found in the pus from the ulcers, in the sanguinolent secretions of the nose, but it could not be obtained from the blood. Hitschmann and Kreibich[85] isolated it in pure culture from two cases of ecthyma gangrenosum with hemorrhagic diathesis and enteritis. It was obtained from the diseased parts of the skin and from hemorrhagic areas in the internal organs. In a later contribution they report another case due to the same organism. Perkins[86] found it in pure culture in a pustular eruption of the inner surfaces of the thighs. This eruption was of the ecthymatous type. Pernet[87] obtained pure cultures of pyocyaneus from the lesions of pemphigus vegetans. Symmers[88] reports a chromogenic micro-organism found in the vesicles of herpes labialis which probably belongs to the pyocyaneus group.

It seems probable that some of the lesions reported as localized skin lesions are only local manifestations of a general infection. In cases where the symptoms are especially severe the probabilities of a general invasion of the body are correspondingly increased.

INFECTIONS OF A MORE GENERAL DISTRIBUTION.

Babes[89] isolated *B. pyocyaneus* from a post-scarlatinous phlegmon. In the organs streptococci were also present. Benfey[90] obtained it from the amber-colored fluid secured by lumbar puncture from a child eight days old. Cultures were made from the spinal fluid, which was withdrawn on account of convulsions, two days before death, and from the brain, pericardial fluid, heart blood, and spleen. In every instance the bacillus was present in pure culture. Boinet[91] obtained it from the blood 24 hours before death in pure culture in a young woman suffering from purulent articular gonorrheal infection. Brill and Libman[92] in a case of septicemia found at first staphylococci. The patient, who was 23 years old, was apparently getting better. This period of improvement was followed by severe septic symptoms accompanied by bronze-colored changes in the skin. Two days before death 6 c.c. of blood were obtained by venous puncture. Cultures made from this blood revealed only *B. pyocyaneus*. Post mortem pyocyaneus was found in pure cultures in the liver, spleen, and kidney. Sections from the organs showed this germ present in large numbers, the capillaries being plugged almost full. In this case the evidence is conclusive of a general pyocyaneus infection occurring in an adult during life. De la Camp[93] contributes a case in a woman of 51 with all the signs of a chronic sepsis. The disease began with pains in the joints. This was followed by a rhinitis with headache. Later fever appeared with purpuric spots and an infiltration of the legs and feet. From the fluid removed from the infiltrated areas during life the pyocyaneus bacillus was obtained in pure culture. Five-tenths of a c.c. of a broth culture grown from the fluid killed a guinea-pig in 14 hours. In the heart blood and in the exudates the same germ was present. Post mortem it was grown from heart blood, verrucous deposits on the mitral valves, and from the spleen. Charrin[94] describes two cases of an infectious process occurring in a brother and sister in which the pyocyaneus bacillus was found. Clinically there were fever, diarrhea, and albuminuria, the symptoms resembling those of typhoid fever or cerebro-spinal meningitis. On the eleventh or twelfth day a vesicular eruption appeared in which this organism was present. One of the children died and from the heart blood the *B. pyocyaneus* was obtained in pure culture. Eastman and Keene[95] report a case of pyocyaneus septicemia in a girl 17 years of age who recovered from her infection. The germ was found in the blood in numerous cultures made from various parts of the body at different intervals. No other germ was present in the cultures. Infection was probably local at first, its primary focus having apparently arisen in a blastomycetic lesion of the skin. Ehlers[96] describes two cases in children, a brother and sister, aged respectively 11 and 12. After a prodromal period there was an elevation of temperature, profuse diarrhea, enlargement of the spleen, mental depression, and prostration. The symptoms suggested typhoid fever or cerebro-spinal meningitis. In about 12 days a papular eruption appeared on the anterior surface of the body and limbs. This eruption became pustular, resembling ecthyma in appearance. The contents of the pustules were blue in color. Ulcers formed with hard borders which were pigmented by hemorrhages. One of the children died with a severe enteritis. From the hemorrhagic pustules and the heart blood the pyocyaneus bacillus was obtained in pure culture seven hours after death. Finkelstein[97] has contributed four cases of pyocyaneus infection in young children. Three of these children suffered from hemorrhagic diatheses during the last few days of their illness. The course of the disease in all three cases was long continued and exhausting. Two of them had otitis media. Besides other organisms *B. pyocyaneus* was found in the organs and blood post mortem. Finkelstein thinks that these infections are not to be regarded as the original cause of the trouble but merely represent a terminal infection which was due to the loss of the normal protective powers of the body. In a fourth case, in a child three months old, Finkelstein obtained from a vein two days before death 2 c.c. of blood. From cultures of this blood he isolated the pyocyaneus bacillus. Fraenkel[98] describes four cases of infection which he thinks were all due to the pyocyaneus bacillus. From Case 1 it was not obtained in culture. In Case 2 it was found in pure culture in pus from the ear, in the heart blood, and in foci in the kidney. In Case 3 it was found in pus from the ear in association with Fraenkel's diplococcus. From the heart blood pure cultures were obtained. In Case 4 the heart blood contained pyocyaneus in pure culture. Huebener's[99] case is of especial interest since it occurred in a man of strong physique who up to the time of his illness had been completely sound. The original lesion was apparently a circumscribed suppurative focus in the region of the sacrum which had extended from the intestine. A general septicemia ensued with metastases in the meninges and kidneys. There was an almost complete suppression of the bowel movement and of the secretion of urine. The pyocyaneus bacillus was present in the purulent foci, in several blood cultures obtained by venous puncture, in the urine in enormous numbers, and in small numbers in the sputum. These cultures were highly virulent for guinea-pigs. Streaks from the liver, kidney, spleen, and heart blood revealed staphylococci in addition. Numerous sections of the involved tissue of the organs showed nearly always smaller or larger numbers of *B. pyocyaneus*. Karlinski[100] reports a generalized infection in which the germ was obtained from the skin vesicles, spleen, blood, and Peyer's patches in pure culture. In a phlegmon of the forearm it was found in association with *Staph. aureus*, the latter organism being found nowhere else. Kossel[101] contributes three additional cases. In the first, which occurred in an atrophic child six weeks old, the pyocyaneus bacillus was obtained in pure culture from the purulent exudate of the pia and from the heart blood. Pus from the ear and fluid from the edematous foci in the lungs contained both the pyocyaneus bacillus and Fraenkel's germ. In the second case, in a rachitic child of two years suffering from measles, death occurred at the end of five days. The illness was characterized by high temperature and symptoms of broncho-pneumonia. In the pus from the ear, from the antrum of Highmore, and the naso-pharynx only *B. pyocyaneus* was grown. In the middle ear itself a few diplococci were found. The third case was in a child four weeks old, illness being ushered in with diarrhea, loss of appetite, and great weakness. The diapers became dark green on exposure to air and the stools were also dark green. There were many pyocyaneus bacilli present in the feces. Most of the common intestinal organisms had been displaced. After much vomiting and many green bowel-evacuations, which rapidly exhausted the child, death occurred on the thirteenth day. The temperature was high, reaching 39.7° C. Pus from the ear and nares, and the mucous secretions from the larynx and trachea revealed only the pyocyaneus bacillus. In this contribution Kossel states that in the investigation of 52 cases he has found the pyocyaneus bacillus eight times, usually in association with other bacteria. Three times it was present in the blood and in the exudates from the middle ears of children. Krannhals[102] records the case of a man who died 27 days after an operation for empyema. This infection took place in a powerful adult. Pus from the mediastinum, pericardial exudate, and material from the spleen showed only the pyocyaneus bacillus in culture. In a second case with similar symptoms only the pyocyaneus bacillus was grown from the intestinal lesions. No typhoid bacilli were present. Kuehn[103] obtained the pyocyaneus bacillus in pure culture in a case of septicemia from the spleen one hour after death. It was also isolated from other organs. Lannay[104] in an exhaustive contribution divides pyocyaneus infections into local and general, the latter being severe septico-pyemias, which nearly always terminate fatally. He affirms that general pyocyaneus infections frequently originate from primary intestinal lesions such as enteritis, dysentery, and typhoid fever. The bacillus is found in the feces, blood, mesenteric glands, and ecchymoses of the mucosa of the intestine. Lannay says he has often isolated this organism from many springs at well-known watering places. Manicatide[105] found this germ in one case in pure culture post mortem in a child

14 months old in the spleen, kidney, and heart blood. In all the other tissues and organs investigated it was found, but not in pure culture. In a second case, in a four-year-old child, a septico-pyemia developed following an attack of diphtheria. The pyocyaneus bacillus was present in pure culture in the spleen, kidney, and heart blood. Neumann[106] records three cases in which *B. pyocyaneus* was present. The first occurred in an infant 13 days old. Death terminated the illness which was characterized by the presence of icterus, petechiae, and hemorrhages of the mucous membranes. The pyocyaneus bacillus was grown from the blood and organs post mortem in pure culture. In another contribution he describes two cases of hemorrhagic diathesis in the new-born. In one of these there was a typical melena. In the other, which occurred in an infant suffering from congenital syphilis, there was a hemorrhagic diathesis. From both cases many colonies of the pyocyaneus bacillus were grown from the pleural and peritoneal fluid, from the intestinal contents, and from the liver and spleen. There were also a few coccus colonies present. In the first of these two cases the *B. aerogenes* was obtained from cultures of the spleen and blood. Oettinger[107] reports the case of an 18-year-old male who, on the twentieth day of an illness, which had been diagnosed typhoid fever, suffered a relapse. On the twenty-fourth day a sudden rise in temperature occurred, accompanied by a vesicular eruption with hemorrhagic contents. The vesicles were present in the greatest numbers on the scrotum, in the groin, and in the lumbar region. From the vesicles the *B. pyocyaneus* was grown in pure culture. Perkins[108] describes a case in a colored infant four months old. After an illness of only a week, during which there were numerous green dejections, the patient succumbed. No cultures were made from the intestines nor from the intestinal contents. In all the organs the pyocyaneus bacillus was present in small numbers in pure culture. In another case it was obtained from the lung in pure culture. There were also miliary abscesses in the brain but no cultures were made from them. In a third case following a burn of the third degree the pyocyaneus bacillus was present in the heart blood in small numbers. Rolly[109] reports a case of general septicemia in a young woman who had aborted. She suddenly showed signs of sepsis, meningitis, etc. On the fourth day of her illness the pyocyaneus bacillus was obtained

in pure culture from her blood and again on the eighth and tenth days of her disease. On the eleventh day she died and the same organism was obtained from the heart blood, kidney, spleen, intestines, and other organs. The point of entrance was apparently the puerperal uterus. Triboulet and Tollemer[110] report a case of septicemia in a child of eight months. It apparently took its origin from disseminated round and cup-shaped ulcers of the skin from which the pyocyaneus bacillus was isolated. Post mortem the germ was found in the heart blood. Sections of the skin showed only a superficial infection, the capillaries not being invaded. Apparently the septicemia had arisen from the skin lesions. Williams and Cameron[111] found the *B. pyocyaneus* in pure culture in two cases in children with clinical symptoms of septicemia. In one it was obtained from the spleen and kidney but not from the heart blood. In the other it was found in pure culture in the liver, spleen, and kidney. The heart blood and urine were sterile. In two other instances it was encountered by them, once in a subcutaneous abscess in association with the *Staph. citreus*, and once in the cecum.

MISCELLANEOUS INFECTIONS.

Babes[112] obtained the *B. pyocyaneus* in pure culture post mortem from abscesses which had their origin in septic umbilical veins. Boynton[113] records a case of infection due to the pyocyaneus bacillus in which the primary focus was in decubitus. Charrin[114] isolated it in pure culture from the greenish discharge of a chronic mastitis and from a tumor of the leg in a young man. The tumor resembled a gumma but there was no evidence of either syphilis or tuberculosis. Curry[115] in the bacteriological examination of six cases of pustule formation found it in pure culture once; in six cases of furunculosis once; in 35 cases of cellulitis three times. Eisenberg[116] reports the case of a man 43 years old, who, four months previous to the time he was first seen, had injured the right leg close to the knee joint. A tumor formed which was very painful. Death occurred at the end of five months. The purulent wound secretions were examined bacteriologically for the first time nine days before death. Plate cultures showed a white coccus and the pyocyaneus bacillus; four days before death a white coccus, pseudo-diphtheria bacilli, and the pyocyaneus bacillus. Jadkewitsch[117] observed a patient who, in the course of 10 years, was attacked with ulcers of the leg three times which were in all probability caused by the pyocyaneus bacillus. In the first attack the blue pus lasted for three months. Five years later it again appeared and lasted three weeks. The third attack appeared three years later and lasted with intermissions for four months. Clinically there was some cutaneous anaesthesia and motor paralysis. The pyocyaneus bacillus was grown from the urine. Lanz and Luescher[118] isolated from the pus, in a case of purulent strumitis, which was incised one month after the beginning of the disease, the pyocyaneus bacillus. Wassermann[119] contributes 11 cases of umbilical infection, four of which were examined bacteriologically. All those examined contained *B. pyocyaneus* in pure culture. In seven of these cases metastases occurred with foci of septic pneumonia in which there was hemorrhagic, cellular, and fibrinous exudation, necrosis, and abscess formation. Inoculations in animals with pure cultures of this germ produced similar lesions.

INFECTIONS OF THE LIVER.

Kruse and Pasquale[120] in the examination of nine cases of liver abscess, in which there was no history or evidence of a dysenteric origin, isolated it three times. Once it was present in pure culture; in the other two cases the cultures were almost pure. In the examination of six more cases complicating dysentery it was never present. The first case was that of a Greek who had lived in Egypt 12 years. Five years previous and again three months before his admission to the hospital he had suffered from a temporary diarrhea. For 20 days he had suffered from pain in the right hypochondrium and in the right shoulder, chills, and fever. Venereal and alcoholic excesses were denied. From the increased liver dulness a diagnosis of abscess of he liver was made. On the same day the liver was punctured. There was little pus present, the blood and pus corpuscles being well preserved. There were no amebae present. Countless colonies of *B. pyocyaneus* were isolated in pure culture.

The second case occurred in a Greek who had always lived in Egypt. He had never suffered from dysentery or diarrhea. Three years before and again one year previous to his admission to the hospital he had had attacks of pain in the liver region but there was no evidence of fever. Two months before he appeared at the hospital the pain again returned, accompanied by chills and fever. The diagnosis of hepatic abscess was made. The abdomen was opened by a longitudinal incision in the right parasternal line under the border of the rib. From the pus, which was very abundant, no amebae could be obtained. On agar plates there was an abundant development of *B. pyocyaneus* with a few colonies of a large motile bacillus which liquefied gelatin and produced gas. Healing of the abscess and recovery followed.

In the third case many colonies of the pyocyaneus bacillus were grown from cultures made from pus taken from the liver and smaller numbers from the peritoneum, spleen, and kidney. There were also present a few colonies of *B. clavatus* and typhoid-like organisms.

In the case of multiple liver abscesses reported below it will be seen that the pain in the right hypochondrium was much less severe and its site was less definitely located than in those of Kruse and Pasquale. The evidence of severe intoxication appears to have been less marked in their cases. From their description one would infer that there was a single focus of infection instead of multiple foci. Diarrhea was common to all but apparently less severe in the cases which they describe.

Case 1.—K. M. American by birth, seven years old. The patient was first seen by Doctor H. J. Lehnhoff on September 7, 1907. She complained of a slight pain in the right side, loss of appetite, and of being hot.

Family History. Three brothers of the patient's father died relatively early—one at the age of 36 of Addison's disease; another at 32 of pulmonary tuberculosis; a third at 32 of the same disease. The history was otherwise negative.

Previous History. The patient had had two attacks of bronchopneumonia, the first occurring at the age of three and the second in May, 1907. From both she apparently recovered in the course of a few days. Except for pain in the epigastric region, of which she complained rather frequently during the last year of her life, she had always been vigorous and seemed to be well in every respect.

Present Disease. On the morning of September 7, 1907, the patient was seen for the first time. Examination revealed nothing except slight tenderness of the abdomen in a circumscribed spot corresponding to McBurney's point. There had been no chill, no abnormality of bowel movements, no vomiting, and very little pain. A tentative diagnosis of catarrhal appendicitis was made. The child was put to bed and an ice bag placed over the tender spot. On the evening of the same day the patient was seen again and found to be in practically the same condition as in the morning. The next day the child seemed to be better and her parents were instructed to let her get up the following day if she continued to do well.

During the next few days she seemed well again and played out of doors as usual. On the twelfth she complained of the same pain again. At this time she seemed to be a little more depressed; the pain was located higher in the abdomen but the area of tenderness could not be definitely located. Her tongue was coated; there was a slight elevation of temperature; and she had little desire for food. No diagnosis was made at this time. Since the symptoms, though rather indefinite, suggested the possibility of typhoid fever, the agglutination test was tried. This proved to be absolutely negative.

A day or two later the child had a chill which lasted for 20 minutes followed by a rise in temperature. From this time on there was a chill almost daily, sometimes two in 24 hours. The temperature rose to a higher point each day until it reached 104° F. One evening the temperature was reported by her parents to be 106° F. On visiting her an hour and a half later it was found to be considerably lower and it never at any subsequent time reached this point. The stools became semi-fluid, were of a reddish-brown color, and the dried fluid portion left a saffron-tinted stain. There was movement of the bowels at least once every day, sometimes twice, without any artificial aid. At this time the patient complained very little of pain and did not seem very ill. During the intervals between her febrile attacks she would get out of bed and walk about the room. About the fifteenth of September it was first noticed that the veins on the right side of the abdomen were somewhat enlarged, being much more clearly visible than those of the left side. There was apparently a mass which could be detected by palpation at the lower border of the ribs on the right side.

Doctor A. R. Mitchell was called in consultation and a diagnosis of acute hepatitis of unknown origin was made. Since the symptoms indicated the probability of pus somewhere and from the fact that some enlargement of the liver could apparently be detected an exploratory incision was advised. This was made on September 20. The appendix was removed since it was found to be enlarged and congested. The liver appeared to be somewhat enlarged and was of a darker color than normal on account of congestion. There was no visible evidence of abscess, nor could any fluctuation be elicited. The gall bladder appeared to be normal.

The patient recovered from the operation but the chills still recurred once or twice daily. There were one or two bowel movements each day, the color changing from a brownish tint to a green. The child now began to vomit and was finally unable to retain either food or water. The chills were frequently followed by a marked collapse. The vomitus and the feces had a very offensive odor. The patient gradually grew worse and died on October 3. On the evening of the same day a partial autopsy was held.

Post-mortem findings.—Unfortunately a complete post-mortem examination was not allowed. The abdomen alone was opened, but there seemed to be very little evidence of anything which would account for the clinical symptoms except the liver. This was found to be considerably enlarged. The surface was smooth and dark colored, and showed marked congestion. There was no evidence of abscess formation on the surface but on section numerous multiple abscesses varying in size from less than a millimeter to one centimeter in diameter were revealed. Cultures were made from the pus on several tubes of inclined plain and glycerin agar and from these the *B. pyocyaneus* was obtained in pure culture. Microscopical examination of stained smears from the pus and from the necrotic walls of the abscesses showed only small bacilli and these were present in enormous numbers. Sections taken from the liver substance also showed many organisms of similar appearance. These appeared to be identical with those obtained from the cultures.

In order to determine the pathogenic effects of this organism inoculations of broth cultures were made in white rats, guinea-pigs, and a rabbit. Three adult white rats received respectively through intraperitoneal injection 1.0, 0.5, and 0.25 c.c. of a 24-hour broth culture grown at 37° C. All the animals died within 48 hours. From the heart blood, spleen, liver, and kidney of each *B. pyocyaneus* was obtained in pure culture.

Four guinea-pigs were inoculated intraperitoneally with broth cultures grown at 37° C. for 24 hours. The first received 1.0 c.c.; the second and third 0.5 c.c.; the fourth 0.25 c.c. All died within 48 hours and cultures made from the heart blood, spleen, kidney, and liver showed only *B. pyocyaneus*.

One large white rabbit received an intraperitoneal injection of 0.5 c.c. of a broth culture of the same organism grown for 24 hours at 37° C. This animal died on the third day, *B. pyocyaneus* being obtained in pure culture from the heart blood.

Guinea-pig No. 5 was immunized in the following manner. On November 21 it received an intraperitoneal inoculation of 1.0 c.c. of a broth culture heated for seven minutes at a temperature of 65° C. Four days later it received 1.0 c.c. of a broth culture heated for five minutes at 50° C. After another interval of four days it received 0.5 c.c. of an unheated broth culture. Five days later it received 1.0 c.c. of an unheated culture grown at 37° C. for 24 hours.

On December 5 guinea-pig No. 5 and a control guinea-pig No. 6 each received 1.0 c.c. of a broth culture of the same organism grown for 48 hours at 37° C. At intervals of from 5 to 10 minutes material was withdrawn from the peritoneal cavity of each guinea-pig and immediately examined in hanging drop. At the end of five minutes material removed from the peritoneal cavity of guinea-pig No. 5 showed some agglutination. At the end of 10 minutes there was some evidence of bacteriolysis and at the end of 30 minutes nearly every organism had undergone solution and disappeared. Guinea-pig No. 6 at the end of 30 minutes showed bacilli in apparently as large numbers and as actively motile as in the beginning of the experiment. There was evidence neither of agglutination nor bacteriolysis.

Culturally the organism, isolated from this multiple infection of the liver, resembled closely *B. pyocyaneus* (*β*) described by P. Ernst. The resemblance was so striking that a description was deemed unnecessary since it would add nothing of value to the literature of the cultural and morphological characteristics of *B. pyocyaneus*.

INFECTIONS OF BONES AND JOINTS.

Pawlowsky[121] isolated *B. pyocyaneus* from a tuberculous joint. Perkins[122] found it in pure culture in one case in abscesses in the region of the seventh rib on the left side and in the left elbow joint. Schuermayer[123] in a prepatellar bursitis, in which there was a serous exudate, obtained from the fluid a pure culture of the pyocyaneus bacillus which he placed between (α) and (β). His case shows that this germ may cause an increased secretion without any pus formation.

The following is the history of another infection of a joint which was obtained through the courtesy of Drs. O. C. Reynolds and E. W. Rowe.

Case 2.—The patient was a young woman about 20 years of age, a Scandinavian by birth. She was married and had given birth to one child. Delivery had apparently been normal and nothing unusual had occurred following parturition. Nothing of importance in her previous history could be discovered except the unhygienic surroundings of her home.

Early in March, 1903, she was taken suddenly ill. There was intense pain and much swelling of the knee joint. The pain was so intense that morphine in large doses gave only partial relief. All the symptoms of an acute osteo-myelitis were present. Fever from the first was high and ushered in with a chill. About 10 days after the onset she was taken to the hospital and a portion of the head of the tibia resected. On opening the joint a large quantity of pus was found. The anterior portion of the articular surface, and the anterior border of the head of the tibia, and the posterior surface of the patella were necrotic, the necrosed portions looking as if they had been gnawed by a rat. At the time of the operation the patient was in a very poor condition. The knee was placed in a plaster cast and kept there for about two weeks. At the end of this time it was decided that an amputation was necessary, since the pain was intense and the patient was rapidly getting worse. The pus had a very offensive odor and when the cast was removed it was found that there was very little evidence of any change in the condition of the lesion except more extensive necrosis of the bones and soft parts. It was therefore thought best to do a mid-thigh amputation. After the operation the stump healed very rapidly and the patient quickly regained her strength. In about two weeks she was discharged with only a slight opening in the stump which had not entirely healed.

From the pus obtained from the joint *B. pyocyaneus* was isolated in pure culture. A microscopical examination of stained spreads of the pus showed only bacilli which were the same in appearance as those grown on culture media. This organism corresponded in almost every detail with the *B. pyocyaneus* (β) of P. Ernst. It is to be regretted that inoculations of this organism were not made in animals to determine its virulence.

SUMMARY.

After reviewing pyocyaneus infections one may perhaps be justified in drawing the following conclusions:

1. That primary infections may be caused by *B. pyocyaneus*.
2. That pyocyaneus infections are not always mild but may be of such severity as to cause death.
3. That lesions of the skin caused by this organism are at times only local manifestations of a general infection.
4. That some infections with symptoms resembling those of typhoid fever, which do not respond to the agglutination reaction for either typhoid or para-typhoid bacilli, may be due to the *B. pyocyaneus*.
5. That the middle ear and intestines are the most frequent foci of infection.
6. That a general septicemia may arise from any primary focus but most frequently arises from an infection of the intestinal tract.
7. That *B. pyocyaneus* may be the specific cause of both sporadic and epidemic diarrheas and dysenteries.

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